## REMARKS

Claims 1-12 and 24 are pending in this application. By this Amendment, claim 24 is added and claims 13-23 are canceled as being directed to a non-elected invention. Support for new claim 24 may be found, for example, in paragraphs [0006] - [0009] of the specification.

Claims 1-7 stand rejected under 35 U.S.C. §103(a) over Itou, U.S. Patent Application Publication No. 2003/0150655A1 and Matoba, U.S. Patent Application Publication No. 2004/0005487A1. Claims 8-12 stand rejected under 35 U.S.C. §103(a) over Itou and Matoba, and further in view of Breed, U.S. Patent Application Publication No. 2006/0212194 A1. These rejections are respectfully traversed.

Applicants claim priority to JP 2002-280317 having a priority filing date of September 26, 2002 and JP 2003-166208, having a priority filing date of June 11, 2003. These priority dates precede the §102(e) effective filing date of at least Matoba. As such, Applicants submit herewith an accurate English translation of the certified priority document JP 2003-166208 to perfect the claim of priority. Priority document JP 2003-166208 provides support for at least, pending claims 1-12 and 24.

In view of the above, at least Matoba does not qualify as prior art, and therefore, a *prima facie* case of obviousness for claims 1-12 has not been established. Accordingly, withdrawal of the 35 U.S.C. §103(a) rejections of all pending claims is respectfully requested.

In view of the foregoing, it is respectfully submitted that this application is in condition for allowance. Favorable reconsideration and prompt allowance are earnestly solicited.

Should the Examiner believe that anything further would be desirable in order to place this application in even better condition for allowance, the Examiner is invited to contact the undersigned at the telephone number set forth below.

Respectfully submitted,

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Attachment:
Petition for Extension of Time
English-language Translation of Japanese Patent Application No. 2003-166208

Date: May 25, 2007

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# CERTIFICATION

I, Azusa Harigane, of TOYOTA TECHNICAL DEVELOPMENT CORP., 1-21, Imae, Hanamoto-cho, Toyota, Aichi, 470-0334 Japan, hereby certify that I am the translator of the accompanying certified copy of the official communications received from the Japan Patent Office in the patent application identified below, and certify that the following is a true and correct translation to the best of my knowledge and belief.

| Application Number | Date of Filing |
|---|---|
| Japanese Patent Application No. 2003-166208 | June 11, 2003 |

Azusa Harigane

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Dated this 25th day of May, 2007

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[PRIORITY CLAIM BASED ON PRIOR APPLICATION]

| | |
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| [APPLICATION NUMBER] | Japanese Patent Application No. 2002-280317 |
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[APPLICATION FEE]

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[LIST OF ATTACHED DOCUMENTS]

| | | |
|---|---|---|
| [NAME OF THE DOCUMENT] | Specification | 1 |
| [NAME OF THE DOCUMENT] | Drawings | 1 |
| [NAME OF THE DOCUMENT] | Abstract | 1 |

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[REQUIREMENT OF PROOF] Required

[NAME OF THE DOCUMENT] Specification

[TITLE OF THE INVENTION] ALERT RELATING TO REMAINING FUEL AMOUNT OF FUEL CELL SYSTEM

[CLAIMS]

[CLAIM 1]

A method of notifying a user of fuel-related information of a fuel cell system, characterized in that

information related to a remaining fuel amount is communicated to the user when fuel of the fuel cell system is consumed in a state where a switch for switching between operation and stop states of the fuel cell system is switched to a stop side.

[CLAIM 2]

The method according to claim 1, wherein

the communication of the information related to the remaining fuel amount includes at least generating an alert for the user when the fuel of the fuel cell system is consumed and the remaining fuel amount falls to an alert generating level.

[CLAIM 3]

The method according to claim 2, wherein

the generation of the alert is implemented when fuel is consumed due to the fuel cell system performing a heat-retention operation.

[CLAIM 4]

The method according to claim 2 or 3, wherein

the alert is sent to an information terminal of the user using wireless communication.

[CLAIM 5]

The method according to any one of claims 2 to 4, wherein

the fuel cell system is mounted in a movable body, and

the alert includes information related to at least one of a remaining fuel amount, a possible heat-retention operation time of the fuel cell system, a possible running distance of the movable body, and a distance to a nearest fuel station.

[CLAIM 6]

The method according to claim 5, wherein

the alert generating level is set such that the possible running distance of the movable body includes a margin with respect to the distance to the nearest fuel station.

[CLAIM 7]

A method of notifying a user of fuel-related information of a fuel cell system mounted in a movable body, characterized in that

information related to a remaining fuel amount is communicated to an information terminal of the user at a location away from the movable body using wireless communication when fuel of the fuel cell system is consumed in a state where a switch for starting the movable body is switched to a stop side.

[CLAIM 8]

The method according to claim 7, wherein

the communication is conducted at predetermined time intervals.

[CLAIM 9]

The method according to claim 7, wherein

the communication is conducted when the remaining fuel amount falls to an alert generating level.

[CLAIM 10]

The method according to any one of claims 7 to 9, wherein

the fuel cell system stops consumption of the fuel in response to a system stop command when receiving the system stop command from the user.

[CLAIM 11]

A fuel cell system, characterized by comprising:

a switch which switches between operation and stop states of the fuel cell system;

a fuel storage unit which stores fuel supplied to the fuel cell system;

a remaining amount measuring unit which measures a remaining fuel amount in the fuel storage unit; and

a communication unit which communicates information related to a remaining fuel amount to a user when fuel in the fuel storage unit is consumed in a state where the switch is switched to a stop side.

[CLAIM 12]

The fuel cell system according to claim 11, wherein

the communication of information related to the remaining fuel amount includes at least generating an alert for the user when fuel in the fuel storage unit is consumed and the remaining fuel amount falls to an alert generating level.

[CLAIM 13]

The fuel cell system according to claim 12, wherein

the generation of the alert is implemented when fuel is consumed due to the fuel cell system performing a heat-retention operation.

[CLAIM 14]

A fuel cell system mounted in a movable body, characterized by comprising:

a switch which switches between operation and stop states of the fuel cell system;

a fuel storage unit which stores fuel supplied to the fuel cell system;

a remaining amount measuring unit which measures a remaining fuel amount in the fuel storage unit; and

a communication unit which sends information related to the remaining fuel amount to an information terminal of a user at a location away from the movable body using wireless communication when fuel in the fuel storage unit is consumed in a state where the switch is switched to a stop side.

[CLAIM 15]

A fuel cell system mounted in a movable body, comprising:

a switch which switches between operation and stop states of the fuel cell system;

a fuel storage unit which stores fuel supplied to the fuel cell system;

a remaining amount measuring unit which measures a remaining fuel amount in the fuel storage unit; and

a control unit which controls an operation of the fuel cell system, wherein

the control unit controls operation of the fuel cell system such that consumption of the fuel is stopped when the remaining fuel amount falls below a predetermined reference value, and a first reference value and a second reference value are set to different values, the first reference value being the predetermined reference value set for a temporary operation in which fuel in the fuel storage unit is consumed in a state where the switch is switched to a stop side, the second reference

value being the predetermined reference value set for normal operation in which the fuel cell system is operated in a state where the switch is switched to an operation side.

[CLAIM 16]

The fuel cell system according to claim 15, wherein

the first reference value is set to a value greater than the second reference value.

[CLAIM 17]

The fuel cell system according to claim 15 or 16, wherein

the first reference value is set to a value that enables normal operation of the fuel cell system to be continued over a time period determined by a predetermined condition or longer.

[CLAIM 18]

The fuel cell system according to any one of claims 15 to 17, further comprising:

a communication unit which communicates information related to a remaining fuel amount to a user when fuel in the fuel storage unit is consumed in a state where the switch is switched to the stop side.

[CLAIM 19]

A movable body in which the fuel cell system according to any one of claims 11 to 18 is mounted, wherein

the switch is a switch for starting the movable body.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[TECHNICAL FIELD]

The invention relates to an art for alerting or notifying a user of information related to a remaining fuel amount of a fuel cell system.

[0002]

[RELATED ART]

If the outside temperature falls to 0°C or below when a fuel cell system is stopped, water inside the fuel cell system freezes, which may cause a trouble in operation thereafter. Therefore, an art for preventing freezing of the fuel cell system has been proposed (for example, see Patent Document 1 and Patent Document 2). In

the art described in Patent Document 1, when the outside temperature falls below an antifreeze temperature, the fuel cell system automatically initiates a heat-retention operation.

[0003]

[Patent Document 1]

Japanese Patent Application Publication No. JP-A-2001-231108

[Patent Document 2]

Japanese Patent Application Publication No. JP-A-7-169476

[0004]

[PROBLEM TO BE SOLVED BY THE INVENTION]

However, if the heat-retention operation is conducted for a long period of time, fuel for the fuel cell system is consumed, and there is a possibility of insufficient fuel during operation thereafter. Such a problem is not limited to a case where the heat-retention operation is conducted for preventing freezing, but rather it is a problem that can occur when the fuel cell system is continuously operated due to any cause.

[0005]

The invention has been made to solve the above-described problem in the related art. It is an object of the invention to provide an art capable of preventing a problem caused by excessive lowering of the remaining fuel amount of a fuel cell system.

[0006]

[MEANS FOR SOLVING THE PROBLEM AND OPERATION/EFFECT THEREOF]

In order to achieve at least a portion of the above-described object, a first method of the invention is a method of notifying a user of fuel-related information of a fuel cell system. The method is characterized in that information related to a remaining fuel amount is communicated to the user when fuel of the fuel cell system is consumed in a state where a switch for switching between operation and stop states of the fuel cell system is switched to a stop side.

[0007]

According to this method, information related to the remaining fuel amount is communicated to the user when fuel is consumed by the fuel cell system

while in a practically stopped state. Therefore, it is possible to prevent excessive lowering of the remaining fuel amount of the fuel cell system.

[0008]

Note that the communication of the information related to the remaining fuel amount may include at least generating an alert for the user when the fuel of the fuel cell system is consumed and the remaining fuel amount falls to an alert generating level.

[0009]

According to this method, the alert is generated for the user when the remaining fuel amount falls to the alert generating level as a result of consumption of the fuel in the fuel cell system. Therefore, at that time, the user can know that the remaining fuel amount is small.

[0010]

It is preferable that the generation of the alert is implemented when fuel is consumed due to the fuel cell system performing a heat-retention operation.

[0011]

According to this method, when the fuel is consumed due to continuation of the heat-retention operation, excessive lowering of the remaining fuel amount can be prevented.

[0012]

It is preferable that the alert is sent to an information terminal of the user using wireless communication.

[0013]

According to this method, even when the user is at a location away from the fuel cell system, it is possible to send the alert.

[0014]

The fuel cell system may be mounted in a movable body, and the alert may include information related to at least one of a remaining fuel amount, a possible heat-retention operation time of the fuel cell system, a possible running distance of the movable body, and a distance to a nearest fuel station.

[0015]

With this configuration, the user can easily take appropriate action in accordance with the information included in the alert.

[0016]

It is preferable that the alert generating level is set such that the possible running distance of the movable body includes a margin with respect to the distance to the nearest fuel station.

[0017]

According to this method, it is possible to move the movable body to the nearest fuel station after receiving the alert.

[0018]

A second method of the invention is a method of notifying a user of fuel-related information of a fuel cell system mounted in a movable body. The method is characterized in that information related to a remaining fuel amount is communicated to an information terminal of the user at a location away from the movable body using wireless communication when fuel of the fuel cell system is consumed in a state where a switch for starting the movable body is switched to a stop side.

[0019]

According to this method, the information related to the remaining fuel amount is communicated to the user. Thus, it is possible to prevent excessive lowering of the remaining fuel amount of the fuel cell system.

[0020]

The communication may be conducted at predetermined time intervals. Alternatively, the communication may be conducted when the remaining fuel amount falls to an alert generating level.

[0021]

If the communication is conducted at predetermined time intervals, the user can know the information related to the remaining fuel amount periodically. On the other hand, if the communication is conducted when the remaining fuel amount falls to the alert generating level, it is possible to notify the user of the remaining fuel amount before excessive lowering of the remaining fuel amount of the fuel cell system.

[0022]

Further, the fuel cell system may stop consumption of the fuel in response to a system stop command when receiving the system stop command from the user.

[0023]

With this configuration, the operation in which fuel is excessively consumed can be stopped by the user command.

[0024]

A first fuel cell system of the invention is characterized by including: a switch which switches between operation and stop states of the fuel cell system; a fuel storage unit which stores fuel supplied to the fuel cell system; a remaining amount measuring unit which measures a remaining fuel amount in the fuel storage unit; and a communication unit which communicates information related to a remaining fuel amount to a user when fuel in the fuel storage unit is consumed in a state where the switch is switched to a stop side.

[0025]

A second fuel cell system of the invention is a fuel cell system mounted in a movable body, which is characterized by including: a switch which switches between operation and stop states of the fuel cell system; a fuel storage unit which stores fuel supplied to the fuel cell system; a remaining amount measuring unit which measures a remaining fuel amount in the fuel storage unit; and a communication unit which sends information related to the remaining fuel amount to an information terminal of a user at a location away from the movable body using wireless communication when fuel in the fuel storage unit is consumed in a state where the switch is switched to a stop side.

[0026]

A third fuel cell system of the invention is a fuel cell system mounted in a movable body, which includes: a switch which switches between operation and stop states of the fuel cell system; a fuel storage unit which stores fuel supplied to the fuel cell system; a remaining amount measuring unit which measures a remaining fuel amount in the fuel storage unit; and a control unit which controls an operation of the fuel cell system. The control unit controls operation of the fuel cell system such that consumption of the fuel is stopped when the remaining fuel amount falls below a predetermined reference value. At this time, a first reference value and a second reference value are set to different values. The first reference value is the predetermined reference value set for a temporary operation in which fuel in the fuel storage unit is consumed in a state where the switch is switched to a stop side, and the second reference value is the predetermined reference value set for normal operation in which the fuel cell system is operated in a state where the switch is switched to an operation side.

[0027]

In this fuel cell system, different reference values are used for the temporal operation and normal operation to determine whether or not the fuel cell system should be stopped. Accordingly, it is possible to prevent a problem caused by excessive lowering of the remaining fuel amount of the fuel cell system during each of the temporal operation and normal operation.

[0028]

It is preferable that the first reference value is set to a value greater than the second reference value.

[0029]

With this configuration, even after operation of the fuel system is stopped during the temporal operation, normal operation can be performed for a certain time.

[0030]

It is preferable that the first reference value is set to a value that enables normal operation of the fuel cell system to be continued over a time period determined by a predetermined condition or longer.

[0031]

With this configuration, even after operation of the fuel system is stopped during the temporal operation, normal operation can be continued over a time period determined by the predetermined condition.

[0032]

The third fuel cell system may further include a communication unit which communicates information related to a remaining fuel amount to a user when fuel in the fuel storage unit is consumed in a state where the switch is switched to the stop side.

[0033]

With this configuration, information related to the remaining fuel amount is communicated to the user. Thus, it is possible to prevent excessive lowering of the remaining fuel amount of the fuel cell system.

[0034]

A movable body of the invention is a movable body in which any one of the above-described fuel cell systems is mounted, and which is characterized in that the switch is a switch for starting the movable body.

[0035]

It should be noted that the invention can be realized in various forms. For example, the invention can be realized in the form of: a fuel cell system and an alert method and a control method thereof; a movable body provided with a fuel cell system and a control method thereof; a computer program for realizing these methods or the function of the system; a storage medium in which the computer program is stored; and a data signal embodied in a carrier wave that includes the computer program.

[0036]

[EMBODIMENTS OF THE INVENTION]

Next, exemplary embodiments of the invention will be described in the following order.

A. System structure:

B. Operations in respective embodiments:

C. Modifications:

[0037]

A. System structure:

FIG. 1 is a schematic structural drawing of an electric vehicle communication system according to an embodiment of the invention. The system includes an electric vehicle (also simply referred to as "vehicle") 100, a communication satellite 200 and a cellular phone base station 300 for wireless communication, and an information terminal 400 carried by a user. The electric vehicle 100 has a fuel cell system 10 as a main power source, and includes a communication unit 20 for performing wireless communication. The communication unit 20 is capable of functioning as an alert generating portion that forwards alerts relating to the remaining fuel amount and information relating to the remaining fuel amount (for example, the amount of remaining hydrogen, possible running distance) to the information terminal 400 via the communication satellite 200 or the cellular phone base station 300.

[0038]

It is possible for the user to use a cellular phone, a house phone, a personal computer, a so-called PDA (portable digital assistant) or the like as the information terminal 400. In addition, a key holder of a key for the electric vehicle 100, or the key itself to which information receiving function and information display function are added may be used as the information terminal 400.

[0039]

Note that, for the forwarding of information to the information terminal 400 from the communication unit 20 of the electric vehicle 100, wireless communication is not necessarily used for the entire route, and wireless communication may be used for only a portion of the route. In the specification, the phrase "using wireless communication" means that wireless communication is used for at least one portion of the route.

[0040]

FIG. 2 is a block diagram showing a main electric structure of the electric vehicle 100. The entire electric vehicle 100 is controlled by a control unit 30. The fuel cell system 10 has a fuel cell control unit 12 (hereinafter referred to as "FC control unit 12"), a fuel cell stack 14, a high-pressure hydrogen tank 16 serving as a fuel storage unit, and a pressure sensor 18 serving as a remaining amount measuring unit. Note that several structure elements of the fuel cell system 10 (air compressor, various valves etc.) are omitted in the figure.

[0041]

The electric vehicle 100 has a secondary battery 40 serving as an auxiliary power source, in addition to the fuel cell system 10 serving as the main power source. The secondary battery 40 is connected in parallel with the fuel cell stack 14 via a DC/DC converter 42. A three-phase inverter circuit 50 creates a three-phase AC power source from these DC power sources, which is supplied to a motor 52 for driving a wheel, and controls the rotational speed and torque of the motor 52.

[0042]

The control unit 30 receives various signals from various sensors. For example, a signal indicating the remaining fuel amount (specifically, pressure) is received from the pressure sensor 18 of the high-pressure hydrogen tank 16, and a signal indicating a remaining capacity SOC is received from the secondary battery 40. Furthermore, the control unit 30 is connected to a navigation system 60 for displaying the travel route of the vehicle and the like.

[0043]

When a key 32 (ignition key) of the electric vehicle 100 is operated to an ON state, each portion including the control unit 30 are activated to create a state allowing operation of the electric vehicle 100 by the user. On the other hand, when the key 32 is set to an OFF state, the control unit 30 stops the operation of each

portion. However, the FC control unit 12 implements a heat-retention operation of the fuel cell system 10 if necessary, regardless of the ON/OFF state of the key 32, when the outside temperature falls to a freezing temperature (for example, 0°C) or below. By generating electric power using the fuel cell stack 14, the heat-retention operation works to prevent the freezing of water in the fuel cell stack 14 and other portions. Consequently, during the heat-retention operation, hydrogen within the hydrogen tank 16 is gradually consumed, thus lowering the remaining amount of the hydrogen. Note that the electric power generated by power generation is used as power for auxiliary machinery such as an air compressor, and as power for an electric heater. However, when surplus electric power is generated, it is used for charging the secondary battery 40. Hereinafter, the description will be made focusing on various processing sequences when such a heat-retention operation is conducted that lowers the remaining hydrogen amount.

[0044]

B. Operations in respective embodiments:

B-1. First embodiment:

FIG. 3 is a flowchart showing a processing sequence according to a first embodiment. The processing sequence is implemented under the control of the control unit 30. However, it may be implemented under the control of the FC control unit 12, instead of the control unit 30. This also holds true in other embodiments to be described later.

[0045]

After the user turns off the key 32 to stop the operation of the entire vehicle (step S1), if the outside temperature falls to a freezing temperature or below, the heat-retention operation of the fuel cell system 10 is initiated (step S2). During the heat-retention operation, the control unit 30 determines whether the remaining hydrogen amount in the hydrogen tank 16 has reached a predetermined alert value (also referred to as "alert generating level") (step S3). Specifically, for example, it is determined whether a tank pressure P measured with the pressure sensor 18 is a preset alert value or less. Instead of this, a tank weight or the like may be measured to determine the remaining hydrogen amount. If the remaining hydrogen amount is the alert value or less, the communication unit 20 sends an alert indicating that the remaining hydrogen amount has reached the alert value to the information terminal 400 (FIG. 1) of the user (step S4). The information terminal 400 notifies the user of

the alert using a screen display and/or sound. Note that the control unit 30 and the communication unit 20 are capable of operating in order to communicate such alerts, if necessary, even when the operation of the vehicle is stopped.

[0046]

Alerts communicated by the information terminal 400 may include a portion or all of the following various information, in addition to the remaining hydrogen amount reaching the alert value.

(1) Current remaining hydrogen amount

(2) Possible heat-retention operation time (estimated time until hydrogen is gone)

(3) Possible running distance

(4) Outside temperature

(5) Vehicle location information

(6) Location information (location, distance and the like) of nearest fuel station (hydrogen station)

(7) Route information to nearest fuel station

[0047]

The information of the above (3) (possible running distance) may be calculated in accordance with the remaining hydrogen amount, or calculated based on both the remaining hydrogen amount and the remaining capacity of the secondary battery 40. The information of the above (5) to (7) can be obtained by using a GPS terminal function of the navigation system 60. Note that these pieces of information may be sent from the communication unit 20 to the information terminal 400 in response to a user request.

[0048]

However, an alert sent to the user preferably includes information related to at least one of the remaining fuel amount, the possible heat-retention operation time of the fuel cell system 10, the possible running distance of the vehicle, and the distance to the nearest fuel station. If designed as such, it has the advantage of allowing the user to easily devise appropriate actions in response to the alert.

[0049]

Thus, in the first embodiment, when the key 32 of the vehicle is set to the OFF state, if the fuel cell system 10 conducts the heat-retention operation and the remaining hydrogen amount reaches the alert value, an alert is sent to a remote user.

As a result, it is possible to prevent the remaining hydrogen amount from becoming excessively low without the user's knowledge.

[0050]

B-2. Second embodiment:

FIG. 4 is a flowchart showing a processing sequence according to a second embodiment. Step S11 (vehicle is stopped) and step S12 (initiate heat-retention operation) are identical to steps S1 and S2 in FIG. 3. After initiating the heat-retention operation, the control unit 30 determines whether the remaining hydrogen amount has reached a first alert value P1 (step S13). If the remaining hydrogen amount has reached the first alert value P1, the communication unit 20 sends a type 1 alert to the information terminal 400 of the user (step S14). Thereafter, the control unit 30 continuously monitors the remaining hydrogen amount, and determines whether the remaining hydrogen amount has reached a second alert value P2 (P2<P1) (step S15). If the remaining hydrogen amount has reached the second alert value P2, the communication unit 20 sends a type 2 alert to the information terminal 400 of the user (step S16).

[0051]

Note that it is possible to set the first and second alert values P1 and P2 to arbitrary values. It is preferable that the alert values P1 and P2 are capable of being arbitrarily changed by the user. In addition, three or more values may be set as alert values.

[0052]

Thus, in the second embodiment, a plurality of alert values is set in advance, and an alert is issued every time the remaining hydrogen amount reaches each of the alert values. Therefore, in the case where the user cannot take action for the first alert, action can be taken for any one of a plurality of alerts. Consequently, it is possible to reliably prevent the remaining hydrogen amount from becoming excessively low.

[0053]

B-3. Third embodiment:

FIG. 5 is a flowchart showing a processing sequence according to a third embodiment. Step S21 (vehicle is stopped) and step S22 (initiate heat-retention operation) are identical to steps S1 and S2 in FIG. 3. After initiating the heat-retention operation, the control unit 30 determines whether the remaining hydrogen

amount has reached the alert value every time a predetermined time passes (steps S23 and S24). If the remaining hydrogen amount has reached the alert value, the communication unit 20 sends an alert (step S25). On the other hand, if the remaining hydrogen amount has not reached the alert value, the process shifts to the following processing in step S26.

[0054]

In step S26, the control unit 30 determines whether or not information related to the remaining hydrogen amount (also referred to as "fuel-related information") has been preset by the user to be periodically sent to the information terminal 400. If set, the communication unit 20 sends the fuel-related information to the information terminal 400 (step S27). On the other hand, if not set, the process returns to step S23. Note that the fuel-related information sent preferably includes at least one portion of information (1) to (7) described in the first embodiment.

[0055]

Thus, in the third embodiment, fuel-related information is sent to the information terminal 400 at predetermined time intervals (i.e., at a predetermined cycle). Therefore, it is possible to obtain information related to the remaining hydrogen amount before the remaining hydrogen amount reaches the alert value. In addition, an alert is sent when the remaining hydrogen amount reaches the alert value, so that it is possible to prevent the remaining hydrogen amount from becoming excessively low without the user's knowledge.

[0056]

Note that in the sequence in FIG. 5, the cycle for sending the fuel-related information and the cycle for determining whether the remaining hydrogen amount has reached the alert value are identical to each other. However, these two cycles may be respectively set to different arbitrary values by the user. For example, the cycle for determining whether the remaining hydrogen amount has reached the alert value can be set shorter than the cycle for sending the fuel-related information. In this case, when the remaining hydrogen amount has reached the alert value, it is possible to send the alert with a little time delay. Alternatively, when the remaining hydrogen amount has reached the alert value, the alert may be immediately sent without waiting for a predetermined time to pass.

[0057]

B-4. Fourth embodiment:

FIG. 6 is a flowchart showing a processing sequence according to a fourth embodiment. Step S31 (vehicle is stopped) and step S32 (initiate heat-retention operation) are identical to steps S1 and S2 in FIG. 3. When the heat-retention operation is initiated, the control unit 30 obtains the current location of the vehicle and the location of the nearest fuel station (hydrogen station) from the navigation system 60 (step S33).

[0058]

In step S34, the control unit 30 calculates the alert value of the remaining hydrogen amount based on the current location of the vehicle and the location of the nearest fuel station. The alert value is set such that the possible running distance of the vehicle when the remaining hydrogen amount reaches the alert value includes a predetermined margin with respect to the distance to the nearest fuel station (the required moving distance). More specifically, for example, the alert value is set such that the possible running distance of the vehicle is a value including a 10% margin over the required moving distance.

[0059]

The control unit 30 determines whether the remaining hydrogen amount has reached the alert value (step S35), and when the alert value is reached, the communication unit 20 sends an alert to the information terminal 400 (step S36).

[0060]

Thereafter, when the user returns to the vehicle and starts the vehicle by turning the key 32 to the ON state (step S37), the shortest route to the nearest fuel station is automatically displayed on the screen of the navigation system 60 (step S38). Accordingly, the user can move the vehicle to the nearest fuel station in a short time in accordance with the display. Note that either the "shortest-time route" or the "shortest-distance route" may be displayed as the "shortest route".

[0061]

Thus, in the fourth embodiment, if the user returns to the vehicle and turns the key ON after an alert of the remaining hydrogen amount is generated, the shortest route to the fuel station is displayed on the navigation screen. Therefore, the user can reach the fuel station in a short time.

[0062]

B-5. Fifth embodiment:

FIG. 7 is a flowchart showing a processing sequence according to a fifth embodiment. In the fifth embodiment, it is assumed that fuel is consumed due to performing normal operation or the heat-retention operation of the fuel cell system 10 prior to the initiation of processing in FIG. 7. In addition, the processing sequence in FIG. 7 is normally executed at predetermined intervals.

[0063]

In step S41, the control unit 30 obtains the remaining hydrogen amount in the hydrogen tank 16. Specifically, the tank pressure P measured by the pressure sensor 18 is obtained as the remaining hydrogen amount. In place of pressure P, a map indicating the relationship between the pressure P and the hydrogen weight may be stored in the memory of the control unit 30 to obtain the remaining hydrogen amount from the map. Alternatively, other parameters related to the remaining hydrogen amount may be obtained as an index showing the remaining hydrogen amount.

[0064]

In step S42, the control unit 30 determines whether normal operation or heat-retention operation is being performed, and shifts the process to step S43 or step S44. In the case of normal operation, in step S43, a system stop reference value applicable during normal operation (hereinafter also referred to as "normal operation reference value") is compared with the remaining hydrogen amount. If the remaining hydrogen amount is greater than the normal operation reference value, the process shifts to step S45 and normal operation is continued without change. On the other hand, if the remaining hydrogen amount is equal to or less than the normal operation reference value, the process shifts to step S46, where the control unit 30 stops the operation of the fuel cell system 10. Accordingly, if normal operation has been performed until then, only the secondary battery 40 (FIG. 2) is thereafter used to perform vehicle operation. Note that "stop the operation of the fuel cell system 10" means a state in which at least the supply of fuel (hydrogen in the present embodiment) is stopped and fuel is not consumed.

[0065]

If it is determined in step S42 that the heat-retention operation is being performed, a system stop reference value applicable during the heat-retention operation (hereinafter also referred to as "heat-retention operation reference value") is compared with the remaining hydrogen amount in step S44. If the remaining

hydrogen amount is greater than the heat-retention operation reference value, the process shifts to step S47 and the heat-retention operation is continued without change. On the other hand, if the remaining hydrogen amount is equal to or less than the heat-retention operation reference value, the process shifts to step S46, where the control unit 30 stops the operation of the fuel cell system 10. Consequently, the heat-retention operation that consumes fuel (hydrogen) cannot be performed thereafter.

[0066]

FIG. 8 is an explanatory diagram showing the relationship between a system stop reference value applicable during normal operation and a system stop reference value applicable during the heat-retention operation. As understood from this example, normally, the system stop reference value for the heat-retention operation is set to a value greater than the system stop reference value for normal operation. This is because if hydrogen is consumed during the heat-retention operation to the point of excessively lowering the remaining hydrogen amount, there is a high possibility of being unable to drive the vehicle to reach the fuel station thereafter. On the other hand, during normal operation, there is a desire to use as much hydrogen as possible to continue operation of the vehicle. The system stop reference value for normal operation, for example, is preferably set to a low value such that the fuel cell stack 14 (FIG. 2) does not deteriorate due to the lack of hydrogen of the fuel cell. On the other hand, the system stop reference value for the heat-retention operation is preferably set to a comparatively large value such that operation of the vehicle can be continued for a certain distance or time. More specifically, the remaining hydrogen amount can be set as the system stop reference value for the heat-retention operation such that the vehicle can reach the nearest fuel station. Note that, in general, respective appropriate system stop reference values should be set for normal operation and the heat-retention operation. Therefore, the two system stop reference values may be set to different values.

[0067]

As described above, in the fifth embodiment, when the remaining hydrogen amount falls below the predetermined reference value during normal operation and the heat-retention operation, the operation of the fuel cell system 10 is stopped so that no further fuel is consumed. As a result, it is possible to prevent excessive consumption of hydrogen by using appropriate reference values that correspond to the operation state.

[0068]

B-6. Sixth embodiment:

FIG. 9 is a flowchart showing a processing sequence according to a sixth embodiment. In the sixth embodiment, the remaining hydrogen amount reading process and the operation mode determination process of the fifth embodiment (FIG. 7) are reversed. Namely, in step S51, the operation mode is determined, and the remaining hydrogen amount is read in step S52a or step S52b. The process in steps S53 to S57 is identical to the process in steps S43 to S47 in FIG. 7.

[0069]

In the sixth embodiment as well, identical to the fifth embodiment, it is possible to prevent excessive consumption of hydrogen by using appropriate reference values corresponding to the operation state.

[0070]

B-7. Seventh embodiment:

FIG. 10 is a flowchart showing a processing sequence according to a seventh embodiment. In the seventh embodiment, step S44 in the fifth embodiment (FIG. 7) is replaced with step S64. Other steps S61 to S63 and S65 to S67 in FIG. 10 are identical to steps S41 to S43 and S45 to S47 in FIG. 7.

[0071]

In step S64, the control unit 30 calculates the remaining driving range of the vehicle based on the remaining hydrogen amount, and compares the remaining driving range with a driving range reference value. The driving range reference value is set to a value such that operation of the vehicle can be continued over a certain distance or time. Specifically, for example, the remaining hydrogen amount can be set as the system stop reference value for the heat-retention operation such that the nearest fuel station can be reached.

[0072]

Thus, in the seventh embodiment, even when performing the heat-retention operation, hydrogen consumption can be stopped in a state capable of performing the operation of the vehicle for the distance specified by the driving range reference value. Therefore, it is possible to prevent excessive consumption of hydrogen by the heat-retention operation.

[0073]

B-8. Eighth embodiment:

FIG. 11 is a flowchart showing a processing sequence according to an eighth embodiment. In the eighth embodiment, step S44 in the fifth embodiment (FIG. 7) is replaced with steps S74a and S74b. Other steps S71 to S73 and S75 to S77 in FIG. 11 are identical to steps S41 to S43 and S45 to S47 in FIG. 7.

[0074]

In step S74a, the communication unit 20 (FIG. 1) sends information related to the remaining fuel amount (fuel-related information) to the information terminal 400 of the user. The fuel-related information preferably includes at least one portion of the seven pieces of information (1) to (7) described in the first embodiment (current remaining hydrogen amount, possible heat-retention operation time, possible running distance, outside temperature, vehicle location information, location information of nearest fuel station, and route information to nearest fuel station). In particular, the remaining fuel amount is preferably included. The information terminal 400 notifies the user of the fuel-related information by screen display and/or sound.

[0075]

If the user judges that the heat-retention operation should be stopped when receiving notification of the fuel-related information, the user operates the information terminal 400 to issue a system stop command. In step S74b in FIG. 11, if the communication unit 20 receives the system stop command, the control unit 30 stops the heat-retention operation of the fuel cell system 10. On the other hand, if the system stop command is not received, the heat-retention operation is continued (step S77).

[0076]

Note that when the system stop command is not received, as described in the aforementioned fifth embodiment to the seventh embodiment, the heat-retention operation of the fuel cell system 10 may be stopped in response to the system stop reference value for the heat-retention operation (reference value for the remaining hydrogen amount or reference value for the remaining driving range).

[0077]

Thus, in the eighth embodiment, information related to the remaining fuel amount is communicated to the user during the heat-retention operation, and the heat-retention operation of the fuel cell system 10 is stopped in response to the user command. Therefore, it is possible to appropriately prevent excessive consumption of

hydrogen in accordance with circumstances such as the location of the stopped vehicle.

[0078]

C. Modifications:

Note that the invention is not limited to the above-described embodiments, and can be implemented in various forms, without departing from the spirit and scope of the invention. For example, modifications such as the following are possible.

[0079]

C1. First modification:

In each of the above-described embodiments, information is spontaneously sent from the vehicle to the information terminal 400 of the user. Instead of this, fuel-related information may be sent from the vehicle when the user sends a request from the information terminal 400. In this case, even if the user is away from the vehicle, it is possible to obtain fuel-related information at any time the user wants.

[0080]

C2. Second modification:

In the above-described embodiments, the high-pressure hydrogen tank 16 is used as a fuel storage unit. Instead of this, a liquid hydrogen tank, a solid metal hydride or the like may be used as a fuel storage unit. In addition, instead of storing hydrogen gas, fuel for reforming (alcohol such as methanol, and hydrocarbon compounds such as gasoline, aldehyde, and ether) may be stored in the fuel storage unit to generate hydrogen by conducting reforming in a reforming unit, which is supplied to the fuel cell stack.

[0081]

C3. Third modification:

The system stop reference value used in the fifth to eighth embodiments described earlier may be set to various values other than described above. For example, the system stop reference value may be determined by arbitrary setting by the vehicle user. Alternatively, the navigation system 60 (FIG. 2) may be used to search the distance to the nearest fuel station, and the system stop reference value may be set to a value that enables the vehicle to run for a distance equal to or longer than the searched distance.

[0082]

Furthermore, the system stop reference value for the heat-retention operation can be set to a value that enables the operation of the fuel cell system to be continued over a time period determined by a predetermined condition or longer. For example, the "time period determined by a predetermined condition" may be set as the time period in which a distance of 20 km can be traveled at a speed of approximately 40 km/h on a smooth road. In this case, even after stopping the operation of the fuel cell system during temporary operation, normal operation can be performed over the time period or distance determined by that predetermined condition.

[0083]

C4. Fourth modification:

In the above-described embodiments, the electric vehicle using the fuel cell system has been described as an example. However, the invention is applicable to movable bodies other than automobiles, such as ships and trains. In addition, the invention is also applicable to stationary fuel cell systems.

[0084]

C5. Fifth modification:

In the above-described embodiments, the key of the vehicle is used to switch between the operation and stop states of the fuel cell system. However, the switch for switching between the operation and stop states of the fuel cell system may also take a form of an arbitrary switch other than the key of the vehicle. For example, in the case of a stationary fuel cell system, a switch for manually switching between the operation and stop of the fuel cell system itself is normally provided.

[0085]

C6. Sixth modification:

The above-described embodiments describe the case where the fuel cell system performs the heat-retention operation. However, the invention is also applicable to a case where fuel is consumed due to some cause when the fuel cell system is stopped by the user. For example, there is a case where the operation of the fuel cell system 10 is continued to continue charging of the secondary battery 40 when the remaining capacity SOC of the secondary battery 40 is lowered when the key is OFF (when the ignition switch is OFF). The invention is also applicable to such a case. Namely, the invention is applicable to cases in which fuel of the fuel cell

system is consumed in a state where the switch for switching between the operation and stop states of the fuel cell system is switched to the stop side. Note that in the specification, an operation mode in which fuel of the fuel cell system 10 is consumed when the key is OFF is also referred to as "temporary operation". The heat-retention operation is one example of the temporary operation.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[FIG. 1]

FIG. 1 is a schematic structural drawing of an electric vehicle communication system according to an embodiment of the invention.

[FIG. 2]

FIG. 2 is a block diagram showing a main electric structure of an electric vehicle 100.

[FIG. 3]

FIG. 3 is a flowchart showing a processing sequence according to a first embodiment.

[FIG. 4]

FIG. 4 is a flowchart showing a processing sequence according to a second embodiment.

[FIG. 5]

FIG. 5 is a flowchart showing a processing sequence according to a third embodiment.

[FIG. 6]

FIG. 6 is a flowchart showing a processing sequence according to a fourth embodiment.

[FIG. 7]

FIG. 7 is a flowchart showing a processing sequence according to a fifth embodiment.

[FIG. 8]

FIG. 8 is an explanatory diagram showing a system stop reference value according to the fifth embodiment.

[FIG. 9]

FIG. 9 is a flowchart showing a processing sequence according to a sixth embodiment.

[FIG. 10]

FIG. 10 is a flowchart showing a processing sequence according to a seventh embodiment.

[FIG. 11]

FIG. 11 is a flowchart showing a processing sequence according to an eighth embodiment.

[DESCRIPTION OF THE REFERENCE NUMERALS]

10... FUEL CELL SYSTEM
12... FUEL CELL CONTROL UNIT (FC CONTROL UNIT)
14... FUEL CELL STACK
16... HIGH-PRESSURE HYDROGEN TANK
18... PRESSURE SENSOR
20... COMMUNICATION UNIT
30... CONTROL UNIT
32... KEY
40... SECONDARY BATTERY
42... DC/DC CONVERTER
50... THREE-PHASE INVERTER CIRCUIT
52... MOTOR
60... NAVIGATION SYSTEM
100... ELECTRIC VEHICLE
200... COMMUNICATION SATELLITE
300... CELLULAR PHONE BASE STATION
400... INFORMATION TERMINAL

[NAME OF THE DOCUMENT] Abstract of the disclosure

[ABSTRACT]

[TASK] To prevent a problem caused by excessive lowering of the remaining fuel amount of a fuel cell system.

[MEANS OF SOLVING THE PROBLEM] If the remaining fuel amount is lowered to an alert generating level when fuel of a fuel cell system 10 is consumed in a state where a switch for switching between operation and stop states of the fuel cell system 10 is switched to the stop side, a communication unit 20 sends an alert to an information terminal 400 of a user. The communication unit 20 may send fuel-related information other than an alert to the information terminal 400 of the user. Further, as a system reference value for stopping the fuel cell system 100 when the remaining hydrogen amount is lowered, different values may be set for normal operation and a heat-retention operation. The fuel cell system 100 may be stopped when the remaining hydrogen amount falls below each reference value.

[SELECTED DRAWING] FIG. 1

[NAME OF THE DOCUMENT] Drawings

[FIG. 1]

ALERT/ FUEL-RELATED INFORMATION

- REMAINING HYDROGEN AMOUNT
- POSSIBLE RUNNING DISTANCE

[FIG. 2]

12/ FC CONTROL UNIT

20/ COMMUNICATION UNIT

30/ CONTROL UNIT

40/ SECONDARY BATTERY

42/ DC/DC CONVERTER

50/ INVERTER

60/ NAVIGATION SYSTEM

1/ REMAINING FUEL AMOUNT

2/ REMAINING CAPACITY SOC

[FIG. 3]

1/ FIRST EMBODIMENT

S1/ VEHICLE IS STOPPED

S2/ INITIATE HEAT-RETENTION OPERATION OF FUEL CELL SYSTEM

S3/ HAS REMAINING HYDROGEN AMOUNT REACHED ALERT VALUE?

S4/ SEND ALERT

2/ END

3/ ISSUE ALERT WHEN TANK PRESSURE P IS EQUAL TO OR LOWER THAN ALERT VALUE

[FIG. 4]

1/ SECOND EMBODIMENT

S11/ VEHICLE IS STOPPED

S12/ INITIATE HEAT-RETENTION OPERATION OF FUEL CELL SYSTEM

S13/ IS REMAINING HYDROGEN AMOUNT EQUAL TO OR LOWER THAN FIRST ALERT VALUE?

S14/ SEND TYPE 1 ALERT

S15/ IS REMAINING HYDROGEN AMOUNT EQUAL TO OR LOWER THAN SECOND ALERT VALUE?

S16/ SEND TYPE 2 ALERT

2/ END

3/ SEND TYPE 1 ALERT WHEN TANK PRESSURE P IS EQUAL TO OR LOWER THAN ALERT VALUE P1

4/ SEND TYPE 2 ALERT WHEN TANK PRESSURE P IS EQUAL TO OR LOWER THAN ALERT VALUE P2 (P2<P1)

[FIG. 5]

THIRD EMBODIMENT

S21/ VEHICLE IS STOPPED

S22/ INITIATE HEAT-RETENTION OPERATION OF FUEL CELL SYSTEM

S23/ HAS PREDETERMINED TIME PASSED?

S24/ HAS REMAINING HYDROGEN AMOUNT REACHED ALERT VALUE?

S25/ SEND ALERT

S26/ HAS PERIODICAL INFORMATION SENDING BEEN SET?

S27/ SEND FUEL-RELATED INFORMATION

[FIG. 6]

FOURTH EMBODIMENT

S31/ VEHICLE IS STOPPED

S32/ INITIATE HEAT-RETENTION OPERATION OF FUEL CELL SYSTEM

S33/ OBTAIN CURRENT LOCATION OF VEHICLE AND LOCATION OF NEAREST FUEL STATION

S34/ CALCULATE ALERT VALUE OF REMAINING HYDROGEN AMOUNT

S35/ HAS REMAINING HYDROGEN AMOUNT REACHED ALERT VALUE?

S36/ SEND ALERT

S37/ VEHICLE IS ACTIVATED

S38/ DISPLAY SHORTEST ROUT TO FUEL STATION ON NAVIGATION SCREEN

END

[FIG. 7]

1/ FIFTH EMBODIMENT (DURING OPERATION OF FUEL CELL SYSTEM)

S41/ READ REMAINING HYDROGEN AMOUNT

S42/ OPERATION MODE?

2/ DURING NORMAL OPERATION

3/ DURING HEAT-RETENTION OPERATION

S43/ REFERENCE VALUE FOR NORMAL OPERATION < REMAINING HYDROGEN AMOUNT?

S44/ REFERENCE VALUE FOR HEAT-RETENTION OPERATION < REMAINING HYDROGEN AMOUNT?

S45/ CONTINUE NORMAL OPERATION

S46/ STOP FUEL CELL SYSTEM

S47/ CONTINUE HEAT-RETENTION OPERATION

4/ RETURN

[FIG. 8]

1/ NORMAL OPERATION POSSIBLE RANGE

2/ HEAT-RETENTION OPERATION POSSIBLE RANGE

3/ REMAINING HYDROGEN AMOUNT

4/ SYSTEM STOP REFERENCE VALUE FOR NORMAL OPERATION

5/ SYSTEM STOP REFERENCE VALUE FOR HEAT-RETENTION OPERATION

[FIG. 9]

1/ SIXTH EMBODIMENT (DURING OPERATION OF FUEL CELL SYSTEM)

S51/ OPERATION MODE?

2/ DURING NORMAL OPERATION

3/ DURING HEAT-RETENTION OPERATION

S52a/ READ REMAINING HYDROGEN AMOUNT

S52b/ READ REMAINING HYDROGEN AMOUNT

S53/ REFERENCE VALUE FOR NORMAL OPERATION < REMAINING HYDROGEN AMOUNT?

S54/ REFERENCE VALUE FOR HEAT-RETENTION OPERATION < REMAINING HYDROGEN AMOUNT?

S55/ CONTINUE NORMAL OPERATION

S56/ STOP FUEL CELL SYSTEM

S57/ CONTINUE HEAT-RETENTION OPERATION

4/ RETURN

[FIG. 10]

1/ SEVENTH EMBODIMENT (DURING OPERATION OF FUEL CELL SYSTEM)

S61/ READ REMAINING HYDROGEN AMOUNT

S62/ OPERATION MODE?

2/ DURING NORMAL OPERATION

3/ DURING HEAT-RETENTION OPERATION

S63/ REFERENCE VALUE FOR NORMAL OPERATION < REMAINING HYDROGEN AMOUNT?

S64/ DRIVING RANGE REFERENCE VALUE < REMAINING DRIVING

RANGE?

S65/ CONTINUE NORMAL OPERATION

S66/ STOP FUEL CELL SYSTEM

S67/ CONTINUE HEAT-RETENTION OPERATION

4/ RETURN

[FIG. 11]

1/ EIGHTH EMBODIMENT (DURING OPERATION OF FUEL CELL SYSTEM)

S71/ READ REMAINING HYDROGEN AMOUNT

S72/ OPERATION MODE?

2/ DURING NORMAL OPERATION

3/ DURING HEAT-RETENTION OPERATION

S73/ REFERENCE VALUE FOR NORMAL OPERATION < REMAINING HYDROGEN AMOUNT?

S74a/ SEND FUEL-RELATED INFORMATION

S74b/ RECEIVE SYSTEM STOP COMMAND

S75/ CONTINUE NORMAL OPERATION

S76/ STOP FUEL CELL SYSTEM

S77/ CONTINUE HEAT-RETENTION OPERATION

4/ RETURN